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SISAL HEMP.

By H. W. Jack, R. O. Bishop and J. N. Milsum.

THE purpose of this paper is to draw attention briefly, to the industrial possibilities of Sisal Hemp (*Agave sisalana*, Perrine.) in Malaya, since records compiled by the Department of Agriculture show that this crop can be grown successfully under local conditions and that the leaves contain a good average percentage of fibre of suitable length and quality. Moreover, as will be shown later, the present supply is insufficient to meet the existing demand for sisal, and there are indications that this demand will increase in the future.

Climate.

Sisal is by nature a tropical plant and its cultivation is most successful only where intense heat prevails during the greater part of the year, but the plant, being very hardy, has gradually become naturalised in most of the warm temperate regions of the globe and appears to thrive well within a belt extending thirty degrees north and south of the Equator.

Being physically adapted to withstand drought, sisal attains its optimum development in regions where a moderately long dry spell is customary, but the plant possesses a wonderful range of adaptability since it has been found to grow well under very humid conditions. Humid conditions accelerate the flowering period, but appear to have no material effect upon the quality of the fibre or upon the percentage of fibre obtainable from the leaves. Such conditions promote regular cropping.

The rainfall appears to be immaterial, provided that where it is low (25-40 inches) the soil is well cultivated and is capable of retaining a fair amount of moisture and that where the rainfall is high, drainage (preferably natural) is satisfactory as nothing retards the growth of the sisal plant so effectively as stagnant water either above or below the surface.

While the chief climatic requirement, assuming that the soil is suitable, is abundant sunshine, seasonal changes are advantageous in that a wet season greatly assists planting operations while dry weather

tends to reduce production costs, though the effect on the total output is unknown at present.

In Kenya, near the coast, sisal is reported to produce a higher percentage of fibre of a finer grade than that grown in the uplands, but inland a larger yield per acre is said to be obtained though in this regard opinions appear to differ and the evidence is inconclusive.

Habitat and Extension.

Sisal Hemp, so called from the name of the port in Yucatan from which it was first exported, is indigenous to tropical South America, Mexico and the Southern States of North America, but has gradually been introduced into most tropical countries and by cultivation has also become acclimatised in most warm temporate regions.

The plant is now well established in Florida, the West Indies, Africa (East, South and West), India Indo-China, the Dutch East Indies, the Philippines, Hawii, Papua, Fiji and the tropical parts of Australia, though commercial success in some of these countries still remains to be proved and depends largely on the abundance of cheap labour and transport conditions. Some closely allied species have even become naturalised on the hills of India up to an altitude of 6,000 feet where the atmosphere is not too moist and where sunshine is plentiful, and excellent crops of sisal are reported in Kenya at 5,000 feet.

The earliest efforts to introduce the fibre into commerce were made in Mexico in 1839, but it was found that the primitive methods of fibre extraction then employed were so tedious and costly even with the cheap labour of that time as to discourage increase of production. Some years later the ofier of a prize led to the invention of a simple machine called the "raspador," and its employment gave the industry the required stimulus, so that it has expanded enormously, Mexico now being capable of producing 150,000 tons of fibre each year.

The industry promises well in East Africa and has already shown signs of rapid extension, the area under sisal in Kenya in 1922 being over 37,000 acres and in Taganyika 61,000 acres were planted in 1913 and the output was over 22,000 tons of fibre, and though the War rather set back the industry in this colony, it is again beginning to flourish. New machinery and cheaper transport tend to promote the commercial cultivation of sisal in other countries also, of which India, Sumatra, the Philippines and Queensland may be mentioned as probable centres of the commercial cultivation on a large scale. It is of local interest to note that in 1923 the Dutch East Indies exported 26,680 tons of sisal fibre of which 75% was shipped to America and the remainder to Holland and Germany.

Botanical.

Sisal Hemp is derived from the leaves of several species of Agave which belongs to the Natural Order—Amaryllidaceae—and much

confusion has arisen with regard to the nomenclature so that it is often difficult to establish the identity of plants yielding the commercial varieties of fibre. According to Professor Dewey there are three species which are concerned in the question of the commercial production of sisal:—(1) *Agave fourcroydes*, Lem., the Yucatan sisal plant which at present furnishes about eighty per cent of the world's supply and which is characterised by marginal spines on the leaves. This species was formerly known as *A, rigida var*: *elongata*, Baker. (2) *Agave sisalana*, Perrine., which is cultivated commercially in East Africa, India, West Indies, Indo-China and Sumatra. (3) *Agave cantala*, Roxb., which is grown in the Philippines, Java and India and produces a finer fibre than *A. sisalana*.

Agave sisalana, Perrine., is now regarded as the source of the standard sisal fibre and its cultivation is rapidly extending. This plant has a short stout trunk bearing a number of stiff and thick fleshy deep-green leaves which terminate in a tough spine. The leaves have smooth margins and a leathery epidermis and range in length up to six feet and in width from 4-6 inches according to age and soil conditions and are arranged in the form of a rosette. At a varying age, depending on climatic conditions, the plant flowers. The flowers are borne in dense clusters at the ends of short lateral branches which arise from the central flowering stem, the so-called "pole" which is some twenty to thirty feet in height. The "pole" at first bears numerous large bracts in the axils of which short lateral branches appear. After the flowers have commenced to wither, buds arise in the axils of the flower stalks. These buds produce small plants called "bulbils" which grow to a few inches in length and then fall to the ground and take root if the conditions are favourable.

The growing inflorescence and the production of bulbils deprive the leaves of their accumulated water and food, so that they become limp, and the plant withers and dies.

Sisal fibre consists of strands 3-5 feet long, nearly white or pale-yellowish in colour. The strands are strong and hard and are composed of a mass of ultimate fibres about 2 to 5 millimetres long which are polygonal in transverse section and have large polygonal lumena. The fibre substance consists of a lignified form of cellulose.

Disease.

Disease in sisal is practically unknown at present, and given tolerably suitable conditions, disease is not likely to be troublesome since the physical structure of the plant renders it naturally resistant to insect and fungoid pests. *Coniothyrium concentricum* is the only fungus disease so far reported as deterimental to the plant. There is a possibility that pig and deer may cause some trouble locally but no damage by these beasts has yet been reported. Scale insects are frequently found on the leaves in Tanganyika and a weevil (*Scyphorus acupunctatus*, Gyll.,) commonly attacks the "poles" just as they are dying, but neither can be regarded as an economic pest.

Introduction to Malaya.

Sisal was introduced into Malaya by the Agricultural Department in 1905, when a small area in Kuala Lumpur was planted at the same time as plots of Bowstring, Manila and Mauritius hemps.

The sisal then showed excellent growth and fibre samples displayed at the Agri-Horticultural Show in Penang in 1909 gained favourable comment.

The experimental block of plants at Kuala Lumpur flowered in 1911 producing sufficient bulbils to plant up several acres in Kuala Lumpur and a similar area at Gunong Angsi in 1912. In addition a fresh lot of material was imported from the Philippine Islands in 1913 and a few acres were planted at Batu Tiga and a small area in Kuala Lumpur.

Thus the present stock of material has been well acclimatised locally and of its hardy and satisfactory growth there is no doubt.

Soils.

It has been shown in East Africa and other sisal growing countries that a porous soil is essential for the successful cultivation of this crop. The root system of sisal is very active, and demands large quantities of oxygen from the air, which is only obtainable through the porosity of the soil. On flat land it is necessary to have efficient drainage as the roots are very impatient of water-logged soil. On undulating land, if effective provision is made against wash, good growth is made. Close silt-pitting appears to assist the growth of the plants by encouraging an extensive rooting system.

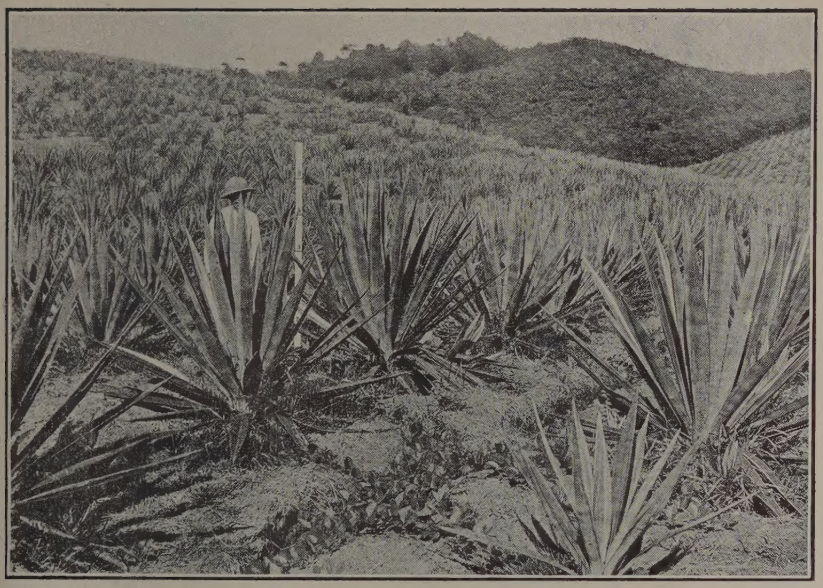
As far as growth is concerned, the average soils found on the western side of the Peninsula appear quite suitable for the requirements for this crop. The best growth is made in soils containing a relatively large proportion of coarse sand, *i.e.*, of a porous consistency. It is probable that excellent growth would be made in the rich chocolate loams obtaining in parts of central Pahang, where suitable areas of land are said to be available.

It is stated that of the mineral requirements of sisal, calcium is the most important and undoubtedly a fair amount of lime in the soil is beneficial to the growth of sisal. At the same time there appears no reason to suspect that plants grown in average land in this country suffer through insufficient lime.

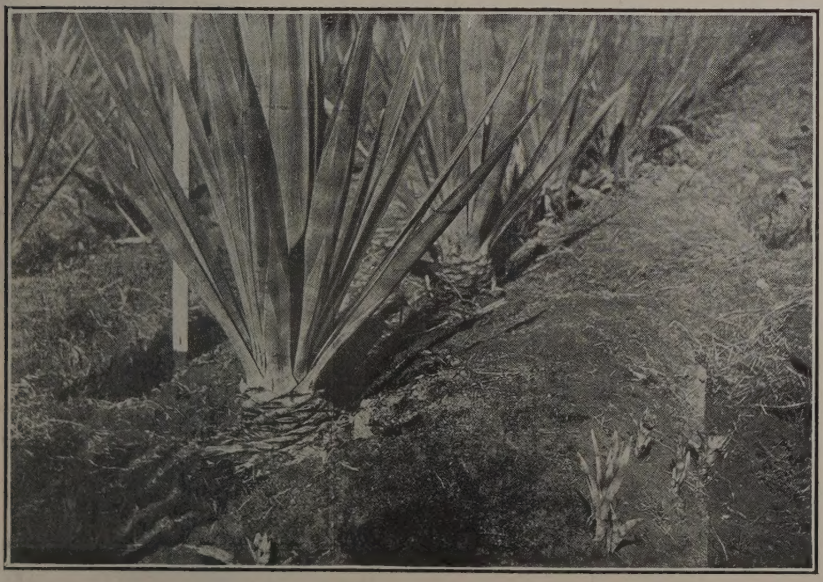
Sisal Hemp will not grow successfully under shade and therefore must be ruled out as a catch crop under rubber.

Methods of Propagation and Nurseries.

There are two methods of propagating sisal, i.e., from bulbils and from suckers. Opinions differ as to which method is the better of the two, though in the case of new plantations, the former is the more economical. Experiments are in operation to test the relative advantages of both methods of propagation.



SISAL HEMP.
Two and a half years in the field.
Experimental Plantation, Serdang, Selangor.
September 1924.



SISAL HEMP SHOWING SUCKERING.
Two and a half years in the field.
Experimental Plantation, Serdang. Selangor.
September 1924.

Bulbils.—Nurseries should be laid out on good land not subject to wash. The beds should be about four feet wide interspaced with paths a foot wide. The surface soil from the paths should be lifted and placed on the beds, resulting in the land being raised, thus affording good drainage. The bulbils usually fall from the poles when they are about six inches long. They should be collected and planted directly in the nursery beds; exposure to the sun as in the case of suckers being unnecessary. Most of the bulbils will show roots and will make rapid headway in the loose soil of the nursery beds. The bulbils are spaced in the beds about one foot each way. No shading or watering is necessary in this climate. Little cultural attention is required beyond periodical weeding. The plants are ready for transplanting to the clearings within a year, when they will be from twelve to fifteen inches high.

The number of suckers produced from a plant pole is given as between 2,000 and 3,000 though from counts made at the Experimental Plantation, Kuala Lumpur, the average was found to be about 1,000. These plants had, however, been heavily pruned and were growing on poor soil that had suffered badly from wash.

Suckers.—On established plantations, suckers may be severed from the plants in the clearings and either grown on in nurseries or planted direct into the field. After collection, they should be placed in full sun for several days to enable the wounds to heal and thus to prevent the plants rotting. It is found necessary to allow suckers about three inches more space than bulbils in the nursery beds. Subsequent treatment is the same as that given to bulbils.

Clearing and Planting Methods.

Sisal is a crop that requires well-cleared land. In the case of virgin jungle, it is necessary to remove considerably more timber than is usual when planting rubber, for the planting distance of the crop is comparatively close and transport of the leaves to the factory is a matter of difficulty with much timber on the land. The ideal condition is clean-cleared land with all the stumps and roots removed, though it is doubtful whether this is possible on account of expense.

At the Experimental Plantation, Serdang, a planting distance of eight feet by eight feet square has been adopted, but this is considered too wide in Java, where five feet by five feet square is stated to be usual. Rows eight feet apart, the plants spaced five feet apart in the rows (giving 1,090 plants per acre) may be sufficient. The rows should run from east to west. Planting should be undertaken during rainy weather. After lining, holes about one foot deep and wide should be dug sometime prior to planting in order to allow the soil to become weathered. The young plants are best planted with the root crown flush with the surface of the soil which should be pressed down firmly.

It is not essential that the land be kept clean-weeded, provided lalang and blukar are kept down. The employment of creeping cover crops is not satisfactory on account of these plants climbing up the

sisal, necessitating constant supervision to prevent the crop becoming smothered. It might be practical to use bushy covers such as Tephrosia. On undulating land, a system of close silt-pitting is beneficial for the purpose of preventing wash and holding as much moisture in the soil as possible.

Harvesting.

The age at which the first cutting may be taken is variable but is usually after the third year. In Java, it is considered unwise to harvest too early on account of the relatively low percentage of fibre in young leaves. The leaves for cutting should be from four to five feet long but the lowest on the plant are frequently less. Maturity is indicated by the leaves bending to an angle of 45 degrees or less from the ground. Vertical leaves are not harvested. The leaf is cut close to the trunk, care being taken not to injure the younger leaves of the plant.

Harvesting is carried out on a definite system to allow of the crop being cut and treated in rotation. The time of harvesting is immaterial in this country, and in this respect sisal is a most accommodating crop as the leaves may be cut when convenient, though the most favourable period is during dry weather when the moisture content of the leaf is at its lowest.

Records of production in this country show that with three to four cuttings per annum an average annual yield of thirty leaves per plant may be obtained. At a planting distance of 8 feet by 5 feet, a yield of approximately 20 tons of green leaves are harvested per annum from mature plants, giving a return of dry fibre approaching one ton.

In Java, on poor land a yield of about 850 lbs. to 1,300 lbs. of dry fibre per acre per annum is obtained, whereas on good land as much as 2,650 lbs. may be secured.

The life of the sisal plant in this country has been found to vary from six to ten years. It is considered necessary, in Java, to replant a sisal clearing after ten years. This is done by replacing each plant which poles with a fresh plant, after the soil has been well changkolled. Land in this country may be insufficiently fertile for this to be possible, and in this case either some form of rotation would have to be instituted or steps taken to improve the soil by green manuring or allowing it to lie fallow for a time.

It is obvious that in dealing with a crop with such a high percentage of waste product as in the case of sisal, a very important item of expenditure will be transport of the raw material to the factory for treatment. The matter must receive attention when selecting the site for the factory, which should be situated in as central a position as possible. On large estates, the cheapest and most satisfactory form of transport is by means of a system of light railways. Permanent lines are laid to feed the factory, connecting with a system of moveable rails from the clearings in bearing. Monorails, as in use on certain oil palm estates, might be employed in the case of sisal cultivation.

In the factory, decortication of the leaves should be completed as soon as possible after cutting but in no case should decortication be delayed beyond three days, otherwise the fibre becomes permanently discoloured.

Treatment of Leaves—Preparation of Fibre.

The preparation of fibre from the leaves of sisal hemp is confined entirely to methods of decorticating the green leaf directly after cutting. Though the process of retting on the lines adopted for flax may be followed by certain native growers, it is established that the decortication of the green leaf can be carried out efficiently, and that the product is superior to that obtained when the leaves are retted first.

Any thought directed to the setting up of suitable machinery for the decortication of the leaves must be based on the fundamental consideration of expedition in handling the crop as it is harvested, and for that reason the factory must be situated centrally with an adequate and reliable water supply. The machinery should be so disposed that the green leaf can be decorticated and the fibre washed and passed to the drying racks within the shortest possible interval.

The essentials of the machinery required to prepare sisal fibre are quite simple, though modern practice and the search for greater efficiency has added improvements which increase the cost. The fibre can be roughly extracted from a sisal hemp leaf by passing the leaf a sufficient number of times through a pair of smooth rollers, such as those used for machining ordinary crepe rubber. The rolling serves to crush the leave cuticle and press the fibre away from its enveloping mass of vegetable tissue; hand washing is sufficient subsequently to prepare a good clean fibre.

In commercial practice, however it would be uneconomic to adopt any form of hand washing and consequently the machine which extracts the fibre must do so in such a manner that no vegetable tissue is left adhering to the fibre. The Raspador machine which was the first and for many years the only mechanical device constructed for this purpose is a rapidly revolving wheel carrying short vanes attached to the outside of its rim. The wheel is arranged to revolve so that the vanes just clear a heavy bed against which the leaf can be pressed and passed backwards and forwards through the intervening space. By this means the leaf is bruised and the fleshy matter scraped away from the fibre, the end of which remains in the hand of the operator.

A machine of this type capable of decorticating approximately one hundred leaves an hour is in use at the Department of Agriculture, and can be inspected by arrangement. It is used for preparing experimental parcels of sisal and other fibres, and cannot be regarded as efficient from an economic and industrial standpoint. The fibre treated by the Raspador requires further treatment to render it completely clean, and this cleansing is only possible by hand washing.

Modern improvements have been directed to the development of a machine which is capable of continuous feeding instead of the intermittent feed of the Raspador and a machine from which the fibre will be delivered throughly free from vegetable tissue. It appears from up-to-date literature that these objects have been achieved in a very great degree. The present sisal decorticator is capable of handling from 100,000 to 150,000 leaves per day, extracting from 2 to 2½ tons of fibre in eight or ten hours' time.

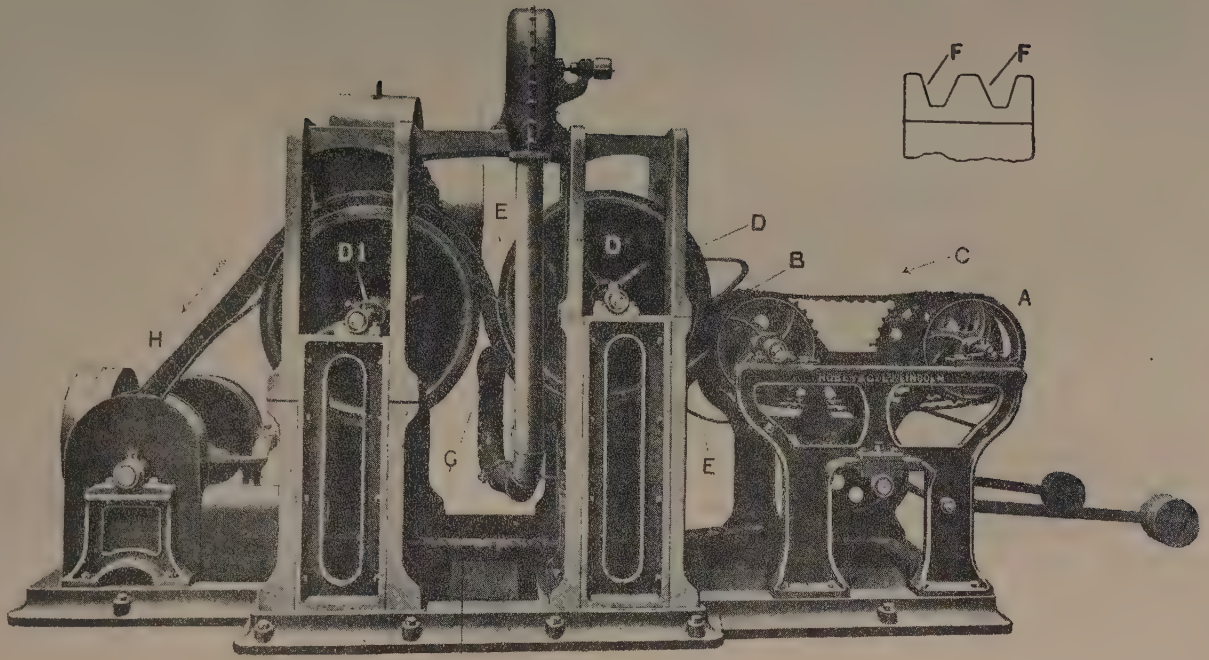
Thus each decorticator should turn out 400 to 500 tons of fibre in a year, and as this represents the leaves cut from, says, 400 to 500 acres, it follows that each area of about 1,500 acres of sisal should have one machine.

The decorticator which has proved most efficient in Yucatan and East Africa is Robey's patent improved machine which can be obtained from Robey Ltd. Lincoln, England.

In this machine (Plate I) the leaves are fed lengthwise on to the three link chains marked A, these working in the direction of the arrow. The leaf marked C, when reaching the point B, will be drawn down and caught between the feed drum D and the conveyor chain E, which goes underneath the feed drum D, the section of the feed drum being as shown on the side of the illustration, the conveyor chain working in the two grooves F. The end of the leaf opposite to that which is held in the feed drum, is drawn along, and the drum and concave, which are working at right-angles, strip off the whole of the pulp and leave only the clean fibre hanging down. When the clean fibre comes opposite the mouth of the blower G it will be blown forward, the other end still being held between the feed drum and the chain. The cleaned fibre is then caught between the conveyor chain E and the second feed drum D1, the chain here passing over the top of the drum. The uncleaned portion of the leaf passes between the second drum and concave, and is duly cleaned, the completely cleaned fibre being delivered at a point H along the chain, a man standing there pulling it on one side.

The two drums are of cast-iron, perfectly balanced and true. The decortication knives, of an angular section, are bolted direct to the drum face and are adjustable by means of liners. The concaves are of phosphor bronze and made in two sections for easy renewal. A perforated copper pipe is arranged above each concave so as to spray water as directly as possible on to the leaves under treatment. A fan is bolted to the top of the machine and pipes are provided to direct the blast into the cleaned fibre coming from the first drum, so as to blow this between the underside of the chain and the second feed wheel. The capacity of Messrs. Robey's "Sixdecor" is 13,000 leaves per hour, or 2 to 2½ tons of fibre per day of eight to ten hours. A 60 b. h. p. engine should be provided to drive it. With a 16 ft. feed table it occupies a floor space 29 ft. 6 in. x 8 ft. 6 in., and weighs about 13 tons.

Where a small machine is required mention may be made of that produced by Lehmann of Manchester which is capable of treating 10,000 leaves daily and is driven by 2 b. h. p. engine.



The "Robey" Decorticator. Diagram illustrating method of working.

Yield of Fibre.

From leaves grown on the several Experimental Plantations, a number of trials have been conducted at the Department of Agriculture, Kuala Lumpur, using crushing rollers and a raspador machine to decorticate the leaves.

The results of this work are detailed below :—

Table I.

Percentage of Fibre in Sisal grown at Kuala Lumpur. Leaves harvested in November, 1921, from plants 6½ years old.

Direct decortication of green leaves.

Number of leaves.	Weight of leaves when cut.	Weight of dry fibre.	Percentage of dry fibre to green leaves.
	lbs.	ozs.	
11	12½	9¾	4.87
11	18	12½	4.34
10	14½	11½	4.96
11	13	8½	4.08
Decortication after retting in still water for 18 days.			
12	16	13.0	5.08
12	16½	12.0	4.54
12	15	9.75	4.06
12	15	10.0	4.27

Following on this preliminary trial, further extractions were carried out in 1924; for the purpose of comparison the leaves were harvested from the plants grown at the Experimental Plantation, Kuala Lumpur, and from other plants at the Experimental Plantation, Serdang, which had been planted in 1921.

TABLE II.

Plantation.	Age of plants. Years.	Date of harvesting.	Number of leaves.	Weight of leaves. lbs.	Weight of dried fibre. lbs.	Percentage dry fibre to green leaf.
K. Lumpur	8	25.7.24	100	147	7.5	5.1
Serdang	3	25.7.24	1,000	812	33.25	4.09
Serdang	3	17.9.24	991	1,274	42.75	3.35
Serdang	3	25.9.25	500	641	22.25	3.4
Serdang	3	4.10.24	400	457	15.75	3.45

These figures show that the sisal plants grown in this country at the two Plantations, yield a proportion of fibre which is comparable with the average yield obtained in the Philippines, Sumatra, Ceylon and East Africa. In Java, the yield of dry fibre, calculated on the wet leaf, varies from 3 to 5 per cent. Leaves from a three year old clearing are said to give 3 to 3½ per cent while leaves from a six to seven year old clearing give 4½ to 5 per cent of dry fibre. The high yield of 5.1 per cent of dry fibre from eight year old plants grown in Kuala Lumbur supports this statement although the sample on which the determination was made was considerably smaller than any of the other samples.

QUALITY OF FIBRE.

According to the standards of grading by the U.S.A.B. Bureau of Standards, the main points requiring consideration in fibre grading are as follows:— strength, colour, extent of cleaning, texture and finally length.

It would be of little value to make any definite statements about the general quality of the fibre produced by the Agricultural Department, or attempt to compare the quality with that of any particular grade of fibre now being offered in the world's markets, because our methods of production are experimental only.

It is however, of value to quote the results of tensile tests which have been carried out on the samples of fibre prepared in different ways and from different sources. The figures given in Tables III and IV for breaking strength are in our opinion indicative of the relative value of the fibre.

TABLE III.

KUALA LUMPUR A.					KUALA LUMPUR B.				SERDANG A.				SERDANG B.			
Number of Samples.	Weight of Sample. Grms.	Breaking Load. Kgs.	Elongation at Break per cent.	Breaking Strength per unit gram length. Kgs.	Weight of Sample. Grms.	Breaking Load. Kgs.	Elongation at Break per cent.	Breaking Strength per unit gram length. Kgs.	Weight of Sample. Grms.	Breaking Load. Kgs.	Elongation at Break per cent.	Breaking Strength per unit gram length. Kgs.	Weight of Sample. Grms.	Breaking Load. Kgs.	Elongation at Break per cent.	Breaking Strength per unit gram length. Kgs.
1	.53	26.6	10%	50.1	.28	11.5	7.5%	41.0	.40	25.7	7.5%	64.2	.40	25.7	7.5%	64.2
2	.53	22.3	7.5%	42.0	.27	10.0	7.5%	37.0	.43	22.8	7.5%	53.0	.43	22.8	7.5%	53.0
3	.43	30.1	7.5%	70.0	.29	11.5	7.5%	39.6	.34	18.5	7.5%	54.4	.34	18.5	7.5%	54.4
4	.51	24.8	7.5%	48.6	.29	13.3	5.0%	45.8	.35	18.3	7.5%	52.2	.35	18.3	7.5%	51.7
5	.51	32.0	10%	56.1	.39	14.3	5.0%	36.6	.43	22.3	7.5%	51.8	.43	22.3	7.5%	51.8
6	.61	26.5	7.5%	43.4	.27	18.7	7.5%	69.2	.38	19.4	7.5%	51.0	.38	19.4	7.5%	51.0
Breaking strength. Average 51.7					.....Average 44.8				.....Average 54.4				.....Average 54.3			

Description of Samples.

Kuala Lumpur A.—Leaves taken from an 8 year old plantation. Green leaf decorticated by machine and washed by hand.

Kuala Lumpur B.—Leaves taken from an 8 year old plantation. Green leaf retted for 14 days then decorticated by hand.

Serdang A.—Leaves taken from a 3 year old plantation. Green leaf decorticated by machine and washed by hand.

Serdang B.—Leaves taken from a 3 year old plantation. Green leaf stored 4 days before decortication and then treated as A.

For the purpose of the above tests " a sample " consisted of 20 strands of fibre cut to 50 cm. in length. Breaking tests were carried out on a Schopper Testing Machine. The length of fibre between the jaws of machine being fixed at 20 cms.

These figures show that the fibre obtained by the retting of leaves is inferior to that obtained by direct decortication of the green leaf. Secondly, the results show that the age of the plant does not cause any material difference in the strength of the ultimate fibre. From figures published by the Philippine Bureau of Science, it appears that the strength of the fibre produced in Malaya is quite as good as anything grown in the former country.

The results recorded in Table III indicate that the samples Serdang A and Serdang B are similar in tensile strength, but when compared as to colour and texture it is found that Serdang B is decidedly inferior. This inferiority is due to different treatment of the samples in preparation; Serdang A samples consisting of fibre which was extracted from freshly cut leaves, whereas in Serdang B samples the fibre was extracted from leaves which had been cut four days prior to decortication and in which decomposition had commenced as indicated by the blackening of the leaf.

In order to gain further information on the effect of delayed treatment of the leaves, that is, decortication of leaves cut and stored in air for one or two or three days, a batch of sisal from Serdang Plantation was cut and transported to Kuala Lumpur where it was divided into six separate bundles. These were decorticated on successive days and the fibre washed and dried in a uniform manner.

The yields obtained are recorded in Table IV. The leaves were cut on 17th September, 1924, from plants three years old. The average length of the leaves was 3 feet 8 inches, and the average breadth 4 inches. 1000 leaves weighed 1,336 lbs.

TABLE IV.

Date treated	Number of leaves.	Weight of leaves. lbs.	Weight of fibre. lbs.	Per cent yield of fibre.
17th	100	123	4.125	3.3
18th	200	273	8.875	3.2
19th	100	135	4.75	3.0
20th	200	256	8.375	3.2
21st	200	243	8.25	3.0
23rd	191	244	8.375	3.4

The fibre from each day's decorticated was treated in three different ways viz:—

(*a*) Removed from the rhaspador machine to washer. Washed 2 hours, then dried in the sun and brushed.

(*b*) Removed from rhaspador to washer. Washed 2 hours. Removed to fresh water, soaked 12 hours, then dried in sun and brushed.

(*c*) Removed from rhaspador to drying racks. Dried in sun and brushed. No washing.

The results of mean weight and relative breaking strength of the fibres from each day are given in Table V.

TABLE V.

Tensile tests of fibre prepared from leaves stored after cutting. Each sample consisted of 20 strands of fibre cut to 50 cms. in length, and each record is the mean of six determinations.

Time of storage of leaf before decortication.	Fibre washed 2 hours before drying.		Washed & soaked for 12 hours before drying.		Unwashed, Dried and Brushed only.	
Days.	Mean Weight	Mean Strength	Mean Weight	Mean Strength	Mean Weight	Mean Strength
	grms.	Kgs.	grms.	Kgs.	grms.	Kgs.
1st	0.37	55.4	0.30	60.0	0.42	54.7
2nd	0.36	48.8	0.37	59.0	0.38	56.0
3rd	0.38	58.3	0.38	62.1	0.41	52.6
4th	0.36	49.1	0.41	48.3	0.36	55.5
5th	0.32	58.0	0.42	56.4	0.35	59.0
6th	0.36	53.6	0.38	59.2	0.36	59.7

Breaking tests were carried out on a Schopper Testing Machine. The length of fibre between the jaws of the machine was fixed at 20 cms. when the load was applied.

A chemical examination of the fibres from the 1st, 3rd and 6th days gave the results recorded in Table VI. The fibres were washed after decortication for two hours and dried.

TABLE VI.

Chemical Examination of Sisal Hemp.

	1st Day Sample.	3rd Day Sample.	6th Day Sample.
Moisture	13.35%	11.72%	10.98%
The following are calculated on the moisture—free sample:—			
Ash.	0.94%	0.88%	0.90%
Water purification loss.	—	0.79%	—
Acid purification loss.	1.31%	0.93%	1.49%
Hydrolysis. A. loss.	12.05%	11.74%	11.11%
Hydrolysis. B. loss.	14.07%	13.74%	14.20%
Cellulose.	78.23%	77.08%	76.20%

From these figures it is evident that there is not any marked deterioration of the fibre owing to storage of the green leaf for two or three days after harvesting.

As long as the leaves themselves did not blacken there was no material depreciation in the colour and appearance of the fibre.

The result of the chemical examination, the losses on hydrolysis and the cellulose content of the fibre from the 1st day's sample indicate a high quality fibre comparable with the best produced in any other part of the world.

Economics.

The economics of sisal cultivation can be examined from various aspects. In the first place the individuality of the plant itself is worthy of consideration. As in all crop cultivation, variation in the degree of development of practically any character under observation is patent, though whether such variations are the expressions of inherent qualities or whether they are merely transitory fluctuations about a "mode" due to differences in physiological reaction to environment is not always easy to determine. However, the fact remains that genetic differences can be revealed by close examination. For instance it has been found that individual sisal plants of the same age grown side by side under apparently identical conditions show very large differences in the number and weight of leaves and in the weight of fibre produced per plant (6.)

Such material differences bear, of course, a most important relation to the successful economic cultivation of sisal and immediately arouse the prospective planter to the value of selection of stock for his plantation, since this factor directly affects the cost of production which is the vital question in the fibre industry. Fortunately, the existing stock in this country shows a high average standard as regards the percentage of fibre obtained from the leaves, though systematic selection, which is already being planned, will undeniably result in improved stock. Selection is rendered easy by the rapid natural vegetative means by which sisal is propagated, though of course, no results can be achieved without the lapse of at least one generation of plants.

Secondly, the crop as distinct from the individual plant requires much thought because the yield of fibre per acre is a factor that goes far in determining whether or not an estate is profitable.

The optimum number of plants which an acre can carry is still a problem in planting economics of which little is known, since sisal growing under cultivation as compared with the prevalent haphazard semi-wild methods existing in Central America is still a comparatively new industry. Experiments are being conducted at Serdang Plantation, Kuala Lumpur, with a view to solving this problem.

The object in view is, of course, to get the maximum crop off the land without unduly robbing the soil of its fertility, and as such,

malaysian-agricultural-

is intimately connected with the problems of the preparation of land for planting and the treatment of the land during the period of the growth of a plantation and of succeeding crops.

The problem, put in a nutshell, is to determine the merits of replanting after a period of fallow or crop rotation as against replanting individual "holes" according as old plants die. Unfortunately, this is a problem which cannot yet be definitely answered as comparative date of yields derived by different methods are not available, for the simple reason that few areas systematically planted have yet reached the stage when the decision becomes necessary. In Kenya, the practice has been to clean the land thoroughly after the plants die and leave it to fallow for about a year or grow two bean crops before replanting. In Tanganyika, three successive crops have been taken from the land; the second and third plantings yielding poorer crops than the first. No doubt, either method of replanting is more economic than natural regeneration (for which the plant is well-adapted) on the grounds of access, transport and the health of the plantation. The problem of maintaining the fertility of the soil is one which the combined activities of the chemist and the agriculturist should solve, probably by the application of an efficient system of manuring coupled with routine cultivation.

Thirdly, due consideration must be given to the most economic size of a plantation, since the cost of machinery is prohibitive for dealing with too small an area.

In Yucatan, the estates vary in extent from 500—2,500 acres. In East Africa, an area of 7,200 acres and the installation of six extraction machines is recommended as the most economic unit (6) but estates of 300—400 acres earn a fair return (15—30%) on capital (3). Owing to the high cost of machinery, it is essential that the plantations should be fairly extensive in order that a large and regular supply of leaves may be available to the factory, which can only be efficient if it is kept working at or near its full capacity. Of course, much smaller areas can combine to produce the leaf necessary to maintain a common decorticator in full working; it might even be possible to establish a village industry on co-operative profit-sharing lines. The chief point is that the most economic machines must be supplied with enough leaf to keep them working regularly and at about full capacity.

The extraction machine shown in Plate I is capable of turning out 2—2½ tons of fibre daily or say 400—500 tons per annum, allowing for stoppages; that is, it will mill the product of about 500 acres of mature plants annually. As the plants require some three years growth to bring the leaves to maturity, it is evident that this type of machine can only be run economically when an area of 1,000—1,500 acres is available. For an area of this size the following planting programme might usefully be adopted. Divide the land into three sections, A, B & C, of approximately equal area. In the first year plant Section A, in the 4th year plant Section B, and plant Section C, in the 7th year. Thus, in the 4 year Section A would be in bearing. This section would be fallowed in the 8th-9th year and

Section B would be in bearing from 7th-11th years. Section B would be put in fallow in the 12th year and Section A would be replanted in the 10th-11th year when Section C would be in bearing. Thus, after the third year, one section would always be in bearing. Though the life of the plant averages locally 8 years, there would always be some leaf worth picking from each section in its ninth year which would add to the product of the next section in bearing so that the decorticator would always be receiving more leaf than that supplied by the actual section reckoned as in bearing.

In Tanganyika (3) in opening up 4,000 acres, it has been recommended that 200 acres should be planted annually and that each 200 acre block, when it has run its course, should be fallowed for several years according to special requirements. This question is very fully discussed by Major Notcutt (6) and the intending planter should study his views closely.

It is not intended that land should be left idle during its entire period of fallow. The land could be used, as in East Africa, to produce beans, or good crops locally might be found in ground-nuts for which there is a good European demand in addition to a thriving and profitable local market.

Fourthly, a survey must be made of local conditions. Under this heading the most vital points are transport facilities, labour supply, cheap and good water supply, soil and climate—economic factors which the experienced planter thoroughly appreciates.

Fifthly, a vital matter in the economic working of a sisal plantation is efficient supervision and management in order to make the best of local conditions, particularly with reference to labour organisation, which is probably the most material factor in cost of production, assuming other local conditions to be fairly favourable.

Supply, Demand and Prices.

The rapid development of modern manufacturing industries has disclosed the high degree of inter-dependence which to-day exists between different and widely separated industries. A few decades ago, it was apparently assumed that the world production of such an important staple as fibre would keep pace with the steadily advancing demand, but the enormously increased use of machinery which marks the progress of modern agriculture, particularly in respect of the cultivation of cereals, has revealed the fallacy of that assumption.

Not only has the consumption of wheat extended amongst white and coloured races of every nationality in the last twenty years, but the increased popularity of wheat as a staple diet is proved by an appreciable rise in the unit of consumption per head of population amongst peoples long accustomed to eat it. The demand for wheat and other cereal foods is steadily becoming more urgent—more land is being devoted to these crops and cheap labour is no longer abundant—hence, necessity has forced the invention and adoption of machinery to till the land and harvest the crop.

The utility of mechanical harvesters depends largely on the abundance of cheap and durable cordage material, and the existing demand for sisal fibre is chiefly due to the rapidly extending use of these machines coupled with the increasing difficulty of growing other suitable fibres. The present annual demand for binder twine in the Western States of America alone amounts to 200 million pounds. This source of demand absorbs almost the entire production of Central America (the principal home of the sisal plant) and the Bahamas, so that little fibre from these sources is available to supply the increasing demand in other countries.

The cultivation of sisal has been given attention in countries other than Central America during the last two decades, and the following table of production shows the extension that has taken place, though the figures cannot be taken as complete.

Production. (in tons.)

	1910	1911	1912	1913	1922
Mexico.	97,000	120,000	139,000	142,250	150,000
Tanganyika.	7,228	11,213	17,079	20,835	10,224
Kenya.	—	—	—	1,073	4,677
Java.	1,000	2,000	6,000	8,700	19,061
Bahamas.	3,000	3,600	3,000	3,236	1,156
Papua.	—	—	—	—	145
Philippines.	2,606	4,484	7,038	6,958	—

Unfortunately, the incidence of War retarded the expansion of the industry despite the fact that during war-time prices soared excessively as can be seen from a perusal of the following figures which give the average price per ton in Europe for each year. The prices are drawn from East African Reports down to 1917. The remaining prices are annual averages collected from reports from various countries, except where the month is mentioned.

Prices. (per Ton.)

1904	-	£36	1911	-	£25	1918	-	£45
1905	-	39	1912	-	30	1919	-	33
1906	-	40	1913	-	33	1920	-	35
1907	-	44	1914	-	29	1921	-	26
1908	-	31	1915	-	23	1922	-	28
1909	-	29	1916	-	32	1923	-	33
1910	-	28	1917	(June)	95	1924	(Aug.)	53

Prices fluctuate each month as may be guaged from the prices for March, June and August of this year which were quoted as £36, £47 and £53 respectively, but under normal industrial conditions

£30 per ton would appear to be a fairly safe figure on which to reckon. The average price for the last 21 years, (omitting the very abnormal war year —1917) was approximately £33 per ton.

Cost of Production.

The cost of cultivating sisal and preparing it for the market varies in different countries according to the local conditions already cited and the extent of operations, and as no data relative to the cost of production per ton of dry fibre in Malaya are as yet available from large scale plantations, inferences must be drawn from results published in other countries. In East Africa, where labour conditions are scarcely as favourable as in this country, the cost of production has been estimated at from £12 to £24 per ton including transport to the railway. Another East African estimate, which appeared in print in June of this year, fixed the return on capital at 25 per cent. basing the estimate on the moderate price of £30 per ton of fibre. The same estimate has been received from Java and the rapid extension of sisal cultivation in the Dutch East Indies, where conditions are very similar to those of Malaya, is significant of the profitable nature of the industry, whilst in Ceylon one estate has recently exported the fibre for the first time with highly satisfactory results. In the Gold Coast, with inexperienced and inefficient labour, the cost of production per ton, including depreciation (10 per cent), interest on capital (6 per cent), and a sinking fund for the repayment of capital (10 per cent.) on an area of 1,000 acres, has been calculated at £19.9.8. Major Notcutt (6) is convinced that costs can be reduced to around £14 per ton of fibre provided that planting is done on a sufficiently large scale and that local conditions are tolerably favourable.

Utilisaton of Sisal Refuse.

In the course of extracting the fibre from the leaf a large quantity of refuse is produced and a good deal of consideration has been devoted to determining the best way of utilising it. The refuse has been used as manure, being returned to the plantation either fresh or as ash after burning, and this practice no doubt helps materially in maintaining the fertility of the land.

The application of the ash to the land would, of course, be the less costly operation but the land will loose the organic nitrogen which the fresh refuse contains and only benefit to the extent of the mineral constituents of the ash, which is very rich in carbonate of lime and contains small quantities of potash and phosphate.

The possibility of utilising the refuse as a material for paper making has been suggested and was tried in Mexico and found to yield a very strong paper, but whether this use has been found profitable is not known to the writers.

It has also been suggested that leaf refuse could be used as a source of alcohol, but it seems doubtful whether the employment of the material for this purpose would be remunerative as considerable difficulty is found in fermenting it.

The waste contains a moderately high proportion of sugar and there is a possibility that it could be used in the dry form, mixed with other materials, as a feeding stuff for stock.

Fresh leaf was reported to have given fairly satisfactory results as cattle fodder.

In Germany, oxalic acid and wax have been prepared from sisal waste and the preparation has been patented.

Conclusion.

It has been shown that the sisal plant thrives exceedingly well in Malaya, that it is not subject to disease and that it produces fibre of good quality, readily saleable in London in large quantities. The increasing difficulty of growing hemp in Europe and the increasing use of binder twine for the machine reaping of cereals have been pointed out and indicate a long continuance of the existing healthy demand for sisal fibre.

In this paper results are given on the experimental work which has been carried out in the Department of Agriculture.

The writers are of opinion that this country is well suited to the commercial development of sisal plantations because of the facilities for the acquisition of suitable land, easy transport, adequate labour and efficient management.

These factors, coupled with the good average price which the fibre has realised during the past twenty years and more, emphasise the possibilities of the establishment of sisal as a sound and remunerative industry in Malaya. Furthermore, by the cultivation of sisal, returns on investment begin to accrue after a period which is fairly comparable to the rubber planting industry.

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2 Bulletin of the Imperial Institute, 1914, 1915, 1923, 1924.

3 Proceedings of the International Congress of Agriculture, 1914.

4 Philippine Agricultural Review, Vol. 16, No. 2, 1923.

5 British East Africa Agricultural Journal, 1909.

6 Sisal Economics—by Major Notcutt, Tropical Life, Vol. 19, Nos. 3 & 4, 1923.

DWARF COCONUTS.

By H. W. Jack.

RECENTLY, there have been so many enquiries regarding the economic aspects of the cultivation of the so-called dwarf coconut, that the following brief notes compiled from information which was kindly supplied from a few estates and from previous issues of the Malayan Agricultural Journal may be found useful.

In the Agricultural Bulletin, F.M.S., Vol. VII No. 3, 1919, the late Mr. W. P. Handover invited attention to the commercial possibilities of the cultivation of the dwarf coconut known locally as the "nyior gading" and showed that the variety must have been imported into Malaya from the Dutch East Indies.

He described the general growth and productive characters of the variety as exemplified by palms up to six years old grown on Sungei Nipah Estate, where 500 acres were planted in 1912 from seed-nuts obtained in the District of Krian, where the dwarf variety has been known to be under cultivation for some 30 years as a popular variety amongst the Banjarese rice planters.

The estimates published at that time were based on only two years of production and were described as conservative.

In the Malayan Agricultural Journal, Vol. X No. 1, 1922, Messrs. Jack and Sands described in detail the chief features of the fruits of the "dwarf" varieties and compared them with those of the "king" coconut of Ceylon and the "coco nino" of the Philippines from which they show decided differences. They pointed out that there were at least three distint types of the local "dwarf" or "nyior gading" variety, recognisable by the colour of their fruits and grouped as (*a*) apricot, (*b*) green, and (*c*) ivory yellow. On existing plantations these types are intermingled with each other and with ordinary talls and semi-talls though the ivory-yellow type predominates. This admixture of varieties is no doubt due, in part, to the fact that in planting these areas, a very large number of fruits had to be obtained from various sources, and it was not always possible to ascertain definitely whether each fruit had been obtained from a typical dwarf ivory-yellow palm. It is quite evident that natural crossing takes place between the tall and dwarf races, so that the semi-talls, or intermediate forms, which occur, are probably first generation hybrids between the talls and dwarfs. At the same time it has been shown that the percentage of seeds which breed true to the fruit colour is very high—as high as 96% in the case of the ivory-yellow variety. The talls may also be hybrids, but they are at present regarded as pure dominants which have segregated out in the 2nd generation of a cross between two races. Only careful breeding experiments can clear up many of the doubtful points connected with the inheritance of these quantitative and colour characters. The different colour types can readily be selected by the colours of the

young leaves of the germinating nuts in the nurseries, and this fact should assist planters very materially in planting out fields so that only the type desired is planted in each field. Not only can colour types be thus separated, but talls and semi-talls can be recognised by the growth characters of the young leaves fairly accurately.

The flowering characters of dwarfs are also described by Messrs: Jack and Sands and they show that, in the low-lands of Malaya where growth is so rapid, self-pollination is of very frequent occurrence.

As regards the commercial or yielding characters of the dwarfs as compared with the ordinary coconut, the following figures show the averages compiled from several estates under good average conditions.

	Ordinary.	Dwarf.
4th year—number of nuts per tree ...	0	15
5th ,, do. ...	5	30
6th ,, do. ...	20	55
7th ,, do. ...	30	75
8th ,, do. ...	40	90
10th ,, do. ...	55	100
Number of nuts per pikul (133 lbs.) of copra ...	260	500
Yield of copra per acre in pikuls after 10 years	9	16
Cost of collection of nuts per 1,000	$1.20 cts.	.40 cts.
,, ,, husking ,, ,, ,,	.65 cts.	.50 cts.
Numbur of trees per acre	48	90
,, ,, nuts ,, ,,	2,500	9,000
Thickness of meat	5/8 inch	½ inch
Average amount of meat per nut	510 grms.	165 grms.
,, ,, ,, copra ,, ,,	240 grms.	125 grms
Average diameter of nut	5½ inch.	4⅓ inch.
,, length ,,	5½ ,,	4¼ ,,

It is generally taken for granted that the life of dwarf trees is only about half that of the ordinary variety, though this supposition is only based on the statements of Banjarese and other cultivators.

Dwarf trees, still bearing quite well though over 30 years old, can be seen occasionally in different parts of the country, but there is no plantation of dwarfs old enough yet to guide opinions, though there seems no reason why they should not produce for at least 30 years under good estate cultivation.

It is, as yet, unknown which type of dwarf is the most productive of copra though the ivory-yellow type is the most popular possibly only because its bright colour attracts the eye more than the duller red and green types do. Theoretically, the green type should be the hardiest and strongest growing type because of the abundance of chloropyll contained in its leaf tissue, and the growth of young palms certainly bears out the theory in practice, though it still remains to be proved whether the green and apricot-red types can compare favourably with the ivory-yellow type from the view point of yield of nuts or copra per tree. The green fruits are usually bigger than those of the

ivory-yellow type. It has been suggested that dwarf palms are more susceptable to "spike moth" attack, but this may only be an environmental effect and in any case, the disease can be controlled.

Dwarf trees may also be used for the production of toddy, though it is said that the yield per flowering spike falls short by about one-third as compared with tall trees. At the same time, dwarf trees usually produce spikes in more rapid succession than tall trees and also they begin to produce spikes some 3-4 years earlier. Another consideration is that that the spikes of dwarf trees, in being situated much nearer the ground, are easier to tap, though the coolie has to tap more spikes to get the same amount of liquid as he gets from spikes of tall trees, and therefore prefers to deal with tall rather than dwarf trees. It is said that Tamils prefer toddy from dwarf to that from ordinary trees, the beverage being sweeter in the former case.

The information contained in this note is purely of a general nature, yet it is hoped that it will supply some of the information which is often requested by those interested in coconut cultivation.

Received for publication 10th April 1924.

INSECT PESTS OF LABUAN AND ADJACENT ISLANDS.

By B. A. R. Gater.

DURING the course of a visit to Labuan in connection with the Zygaenid pest of coconuts, *Artona catoxantha*, Hamps., several other insects of economic importance were noticed, and it is thought advisable to publish the details owing to there being very little information on record as to the economic fauna of this district. The information is not by any means complete, being the result of casual observations made during the odd moments of a week's work on the main object of the visit.

Crops in the past have been limited in number, but owing to the activity of Mr. W. W. Boyd other crops are being brought in and encouraged among the native cultivators. It is therefore of some importance that a little knowledge of the insect pests in the area should be forthcoming, especially since Labuan, although forming a part of the Straits Settlements has not had the advantage of a resident representative of the Agricultural Department.

Coconuts.

Artona catoxantha has twice appeared on the island of Pulo Kuraman, the second outbreak being of a more severe nature than the first. This pest has also appeared at Labuan and Rusukar Kechil at the same time as on Pulo Kuraman, and it is reasonable to presume that the moths spread to these districts from the centre of the attacks at Kuraman. The distances are from $1\frac{1}{4}$ to 2 miles, and in this respect it would appear that the moths have much greater powers of flight, aided probably by wind, than has been noticed in the Federated Malay States. During the last attack the moths appeared at Kiamsam Point, Labuan, 2 miles from Pulo Kuraman, after the S. W. Monsoon had broken. They did not lay eggs, and as far as could be ascertained they had probably already completed oviposition before being driven over to the larger island. At Pulo Kuraman Sago palms were attacked, but Areca palms were untouched.

The absence of the large number of parasites usually associated with the later stages of outbreaks of this pest indicates that it may have been imported. When and how this occurred cannot be stated, but it does not appear that it came from Labuan. A careful search among the coconuts there neither revealed the presence of moths or cocoons nor any signs of the typical feeding marks made on the leaves by the caterpillars.

Parasites were few in number, not more than 5% of the caterpillars having been attacked. Evidences of the presence of the Clerid *Callimerus* sp., and cocoons of an Ichneumonid parasite, probably *Goryphus* sp., were seen. One caterpillar had been attacked by a polyembryonic Chalcidoid similar to one observed at Batu Gajah,

F.M.S., in 1923. The Tachinid parasites common in the F.M.S. could not be found, and 250 adults collected at Lenggong, F.M.S., were released.

A batch of 400 was originally collected, but owing to slight differences in the times of the life histories of the pest at Lenggong and Pulo Kuraman some were lost through emerging on the voyage. A total of 20% of the puparia collected was affected by various hyperparasites, which is unusually high, and some care had to be taken not to release the hyperparasites with the parasites. Further details of the results of the investigations will be incorporated in another paper devoted to *Artona catoxantha*.

Apart from the above-mentioned pest the coconuts at Pulo Kuraman were remarkably clean. At Labuan, however, the damage done by the Rhinoceros Beetle (*Oryctes rhinoceros*, L.) is severe, no measures having been taken in the past to clear away old coconut stumps and logs, most of which contained the grubs of this insect. The Red Stripe Weevil (*Rhynchophorus schach*, Oliv.) was also present. The Lesser Spike Moth (*Batrachedra arenosella*, Walk.) could not be found. Other insects on coconuts were :—

Tirathaba sp. nr. *trichogramma*, Meyr (Pyralidae).
Amathusia phidippus, L.
Limacodid, prob: *Setora* sp.
Valanga nigricornis, Burm. (Acridiidae).
Aspidiotus destructor, Sign.

Rice.

Padi, both wet and hill varieties, was being planted out at the time, and the nursery plants appeared healthy. One nursery had been attacked by a caterpillar, which from the description given would appear to be *Spodoptera* sp. The following insects were seen :—

Cnaphalocrocis medinalis, Guen. (Pyralidae).
Nephotettix bipunctatus, F. (Jassidae).
Oxya sp. (Acridiidae)

Several other insects were seen in the padi nurseries, the Hesperiid, *Padraona gola* (?) Moore, being common. The sweet potatoe pest, *Cylas formicarius*, F. was present in the young padi, as were also the Carabid, *Casnoidea cyanocephala*, F., and *Alesia discolor*, F. (Coccinellidae).

Hibiscus spp.

Owing to the importance of insects affecting plants of this genus to cotton, roselle and other crops, the following list of insects found on Hibiscus is of considerable interest :—

Earias fabia, Stoll.
Dysdercus cingulatus, F.
Pseudococcus citri, Risso.
Saissetia nigra, Nietn.

In addition to the above two Pyrrhocorids and a Coreid were found which had not been recorded in our economic records. They were submitted to the Systematic Entomologist, F.M.S. Museums (H. M. Pendlebury) who considered No. 1623, to be *Odontopus* sp., No. 1624 *Dysdercus* sp. approaching *D. simplex*, Wlk., and No. 1651. *Serinetha* sp., possibly a local race or new.

Fruit.

Citrus trees appeared to be fairly healthy, few insects having been seen on them. *Papilio polytes*, L., *Aleurocanthus spiniferus*, Quaint. and *Pseudococcus citri*, Risso. were observed. Bananas were attacked to a small extent by *Erionota thrax*, L., while Psyllid galls were present in some numbers on *Eugenia malaccensis*. An unidentified Coccid was present on many specimens of *Artocarpus Kuntsleri*, giving rise to large quantities of "sooty mould." Mango was infested with Jassid nymphs, apparently *Idiocerus* sp. and it was reported that during the fruiting season a large number of fruits are affected by a beetle, which is probably *Cryptorhynchus mangiferae*, F.

Miscellaneous,

Adoretus compressus, Weber. (Rutelinae) and the Melolonthid, *Apogonia cribricollis*, Burm. appeared to be the most common night-feeding beetles, but were only noticeable in gardens, not having been complained of on field crops.

Locusts appeared in Labuan in 1919 and did some damage to the padi fields. Judging from a report by P. B. Richards, who visited the island at the time, the insect was identical with the one which was present in the F.M.S. in 1912—15, *i.e.*, *Locusta migratoria*, L. There was an outbreak of locusts in British North Borneo at the same time, and the swarms had evidently spread from there to Labuan. Communications are being established with scientists in B. N. Borneo with the object of studying points on the biology of this locust, many of which are obscure.

Received for publication 11th October, 1924.

THE RESOURCES OF THE EMPIRE:— RUBBER, TEA AND CACAO Etc.*

By W. A. MacLaren.

(*A Review.*)

IN a brief foreword H. R. H. the Prince of Wales opens this valuable book by likening it to a stock-taking of the natural products of the Empire, and thus emphasises its need in Empire economics.

In the "General Introduction" Sir Eric Geddes points out that there has been no standard work of reference giving the information required by business men throughout the Empire and that the aim of this book is to provide a compendious buyers' guide to our imperial resources. He shows that British imports from imperial sources have advanced considerably since 1923, and briefly summarises the area and population of the Empire pointing out the almost unlimited field for expansion of Empire trade along the lines of development of material resources. H. Eric Millar in an "Introductory Review" alludes to the important part played by the British race in the development of the World's natural resources and appeals to the present generation to honour the pioneers whose enterprise and daring opened so many doors in the past. He emphasises the importance of applying scientific research to tropical agriculture and the nature of the long risk to which planters of permanent crops are exposed, as compared with annual crops.

The Editor's foreword portrays the enormous scale of tropical agricultural production in the Empire and explains the imperial aspect of surplus production. The economic aspects are briefly touched upon and methods for conserving surplus production are suggested, while extension of British capital and enterprise to industries other than rubber and cacao, such as fibre, is hinted.

The pressing need for co-ordinated colonial agricultural policy is stressed and a strong plea is made for more deliberate directive effort towards guiding the ignorant native producers in their choice of cultivations and getting them firmly settled on the land.

In early chapters the development of the rubber, tea and cacao industries are traced, and the histories of the slumps of 1920-21 are outlined together with explanations for their cause.

The methods of cultivation and preparation for the market of each crop are described; the organisations of the London markets are explained and some anomalies pointed out *e. g.*, purchase of rubber by appearance and not by quality.

The statistics of supply and consumption of each product in the world and in the Empire are given, and geographical surveys embracing statistics of acreage, acre yields, production prices and production

costs and average profits earned in each industry in each producing country within the Empire. Research organisations, disease control, local markets, labour and native methods are described in dealing with the principal industries. There is an interesting chapter describing little-known industries in products related to rubber—jelutong, guttapercha, balata and chicle—and the section dealing with spices is of interest in that it explains the cultivation, preparation for the market and trade in commodities with which few people are familiar. The book concludes with a useful chapter on tobacco which is treated with the same detail as to statistics and geographical survey as is portrayed in other crops. The book certainly fulfils its aim in forming a compendious buyers' guide and should prove interesting reading to all who have the advancement of the Empire at heart, whether they be planters, traders or professional men.—*H.W.J. 1-7-24*

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THE DETERMINATION OF THE BEST METHOD OF ESTIMATING POTATO YIELDS.

By R. N. Salaman.

Journal of Agricultural Science, Vol. XIII, Part 4, 1924.

THIS interesting paper, though based on work with the potato, is applicable to other annual crops.

It is commonly thought that the accuracy of yield determinations can only be reliable when they are based on large amounts taken from comparatively large blocks of land. This paper discloses the fallacy of this opinion and proves that, for the potato crop, a sufficient degree of accuracy (less than 5% of the crop) is obtained by using plots 1/160 of an acre in area, provided that not less than five duplications are used in the determination.

The experiments were carried out with plots of all sizes between 1/1635 and 1/21 of an acre, and with from 5 to 75 duplications.

The measure of accuracy employed throughout the experiment was the size of the probable error of the mean calculated by the method known as the "least squares" for different groups of plots arranged either end to end or side to side.

The paper also shows that long narrow plots are the most reliable for experimental purposes apart from the ease of working a narrow as opposed to a square plot. Moreover, a long plot is easier to supervise, (which is a material consideration,) much cheaper to work and in general, the shape of a plot is of far greater importance than its size.

In practice, the soils of most fields vary in some given direction and long narrow plots can be placed so that their long axis corresponds with the direction of soil variation, and thus the error from this factor is reduced to a minimum or even entirely excluded.

The results tabulated in the paper should prove of considerable value to workers dealing with annual crops locally.

H.W.J.